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(54) **SYSTEM AND METHOD FOR FIBRECHANNEL FAIL-OVER THROUGH PORT SPOOFING**

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(51) **Int. Cl.**[7] **G06F 11/00**
(52) **U.S. Cl.** **714/3**; 714/5
(58) **Field of Search** 714/3, 5, 13, 48

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(57) **ABSTRACT**

In a system for appliance back-up, a primary appliance is coupled to a network, whereby the primary appliance receives requests or commands and sends a status message over the network to a standby appliance, which indicates that the primary appliance is operational. If the standby appliance does not receive the status message or the status message is invalid, the standby appliance writes a shutdown message to a storage device. The primary appliance then reads the shutdown message stored in the storage device and disables itself from processing requests or commands. When the primary appliance completes these tasks, it disables communication connections and writes a shutdown completion message to the storage device. The standby appliance reads the shutdown completion message from the storage device and initiates a start-up procedure. This procedure causes the address of the standby appliance to be identical to the primary appliance address, and the standby appliance processes the requests or commands in place of the primary appliance.

24 Claims, 7 Drawing Sheets

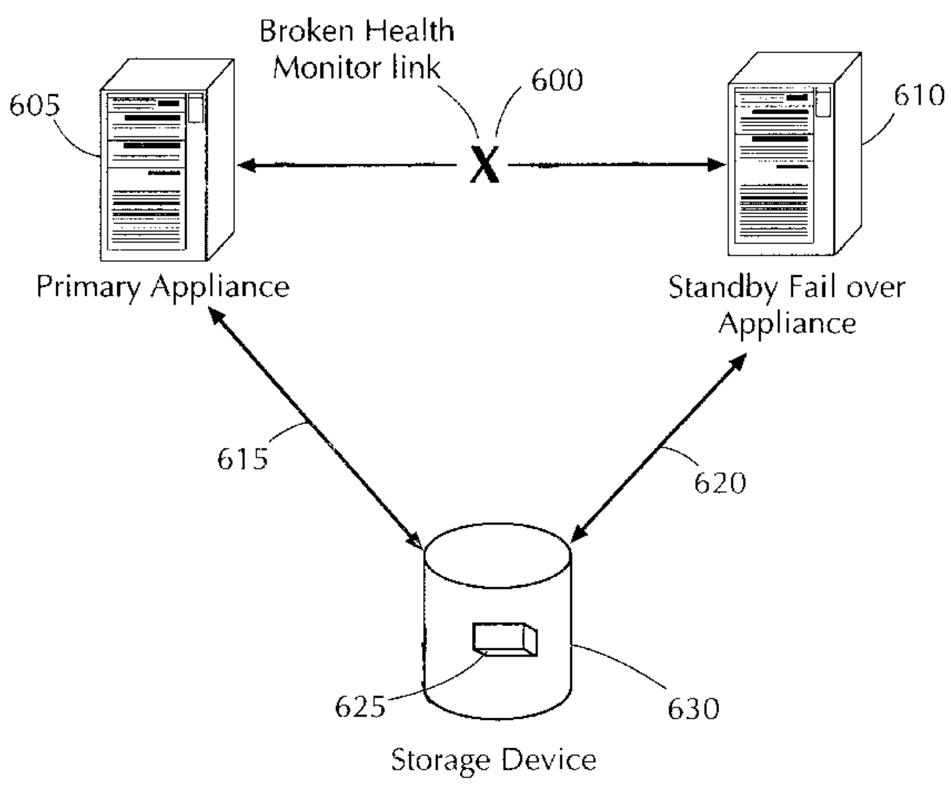

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FIG. 1
(Prior art)

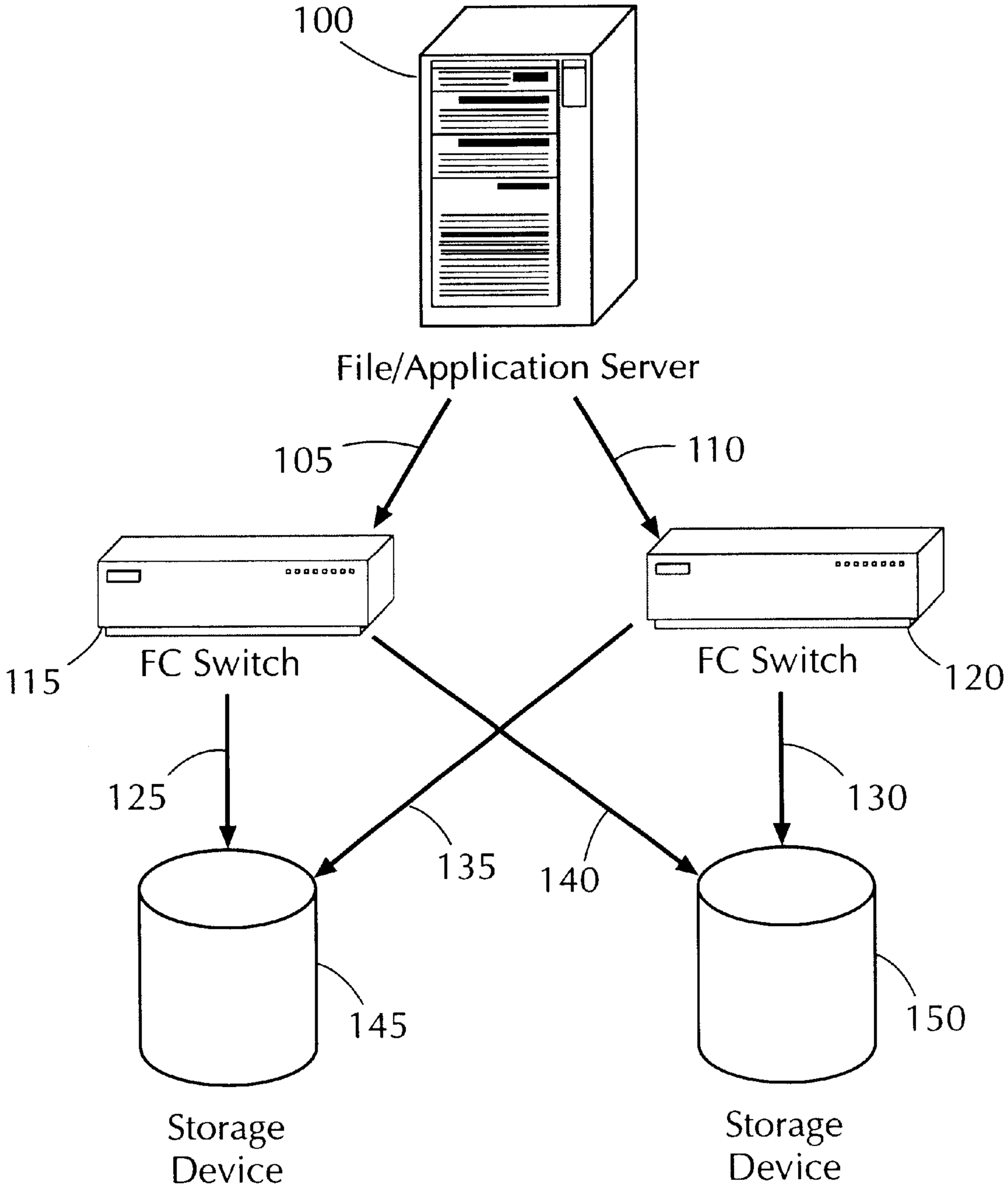
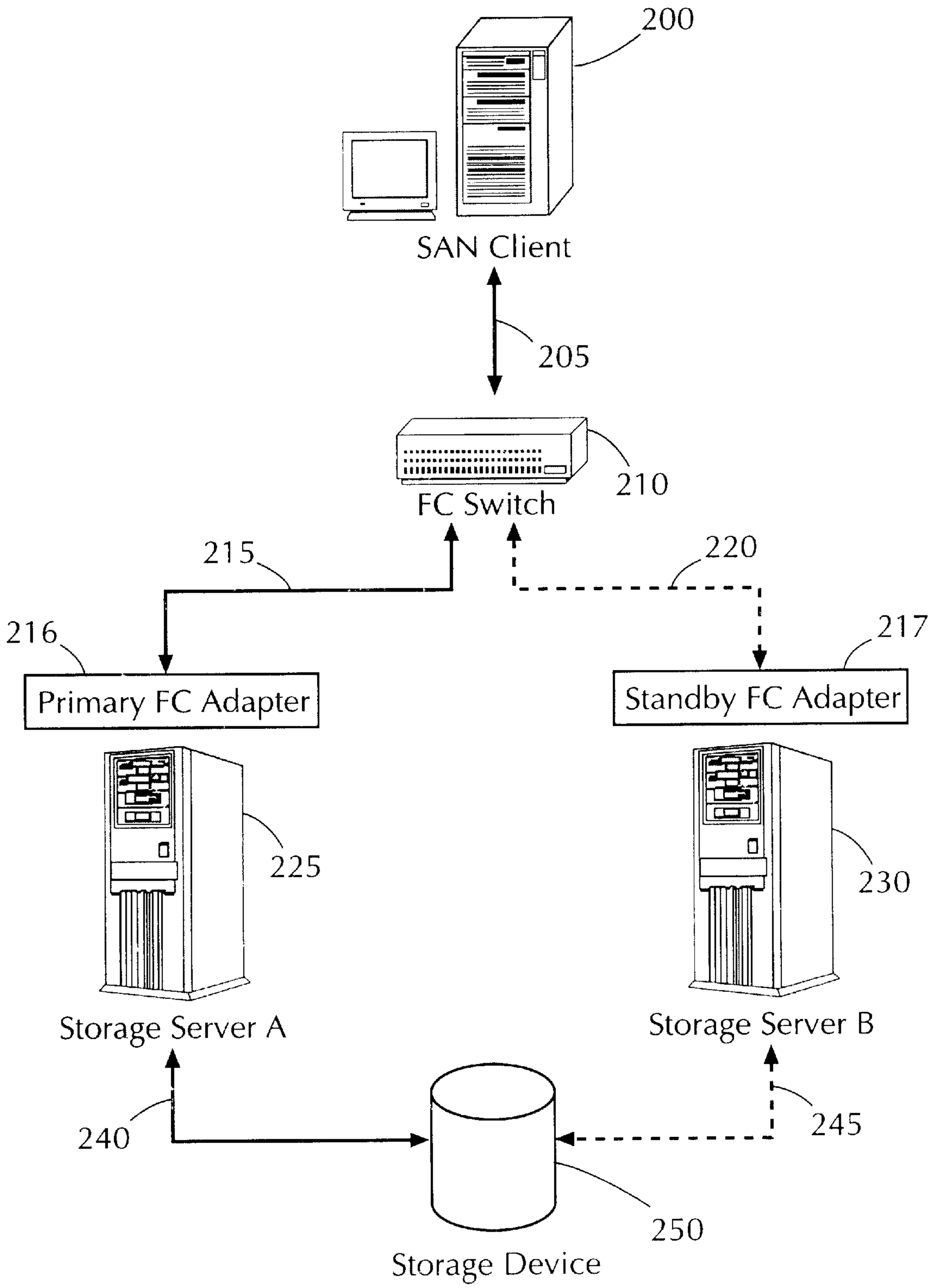


FIG. 2


200
SAN Client
205
210
FC Switch
215
220
216
217
Primary FC Adapter
Standby FC Adapter
225
230
Storage Server A
Storage Server B
240
245
250
Storage Device

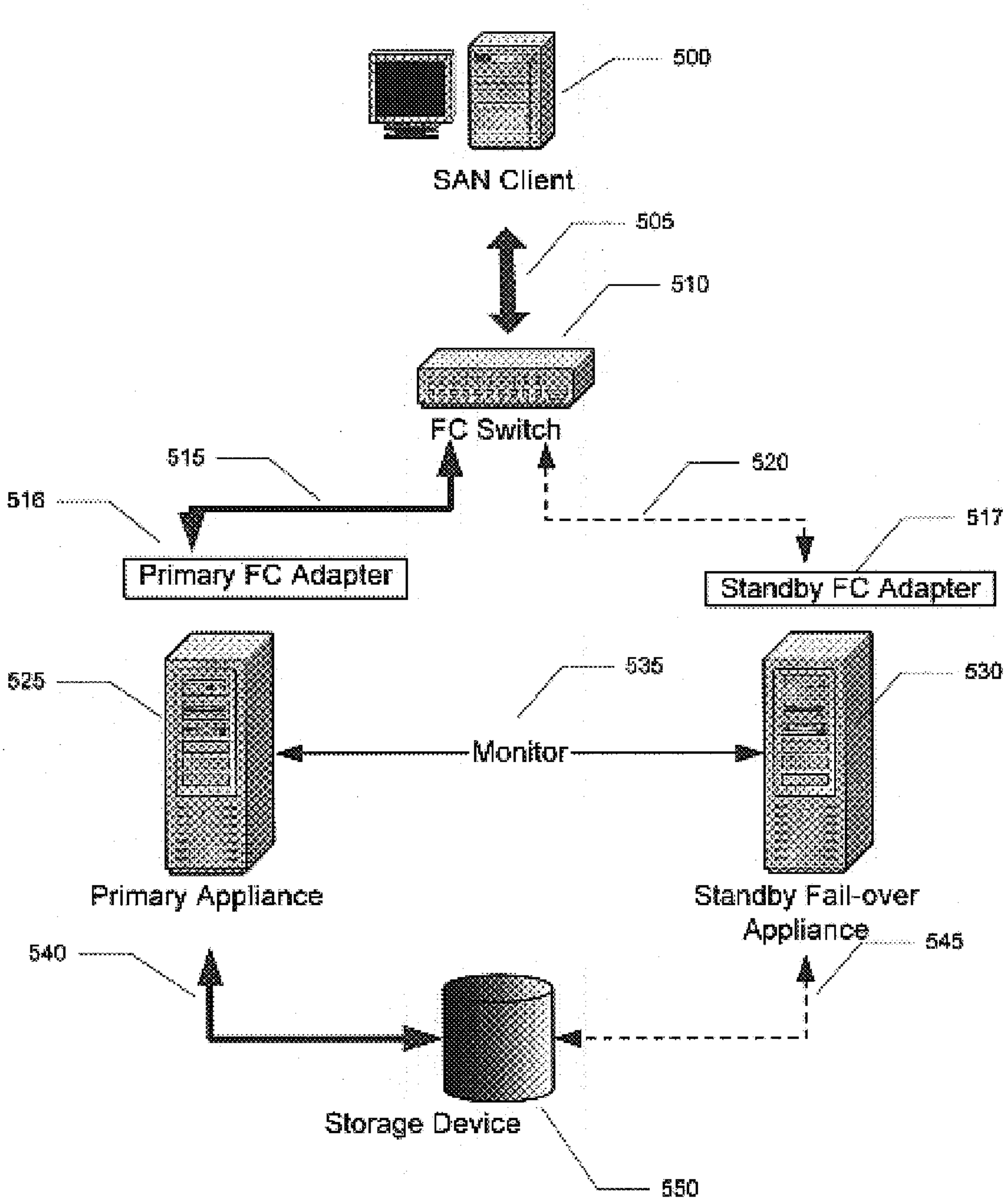

500
SAN Client
505
510
FC Switch
515
516
520
517
Primary FC Adapter
Standby FC Adapter
525
535
530
Monitor
Primary Appliance
Standby Fail-over Appliance
540
545
Storage Device
550

Figure 3

FIG. 4

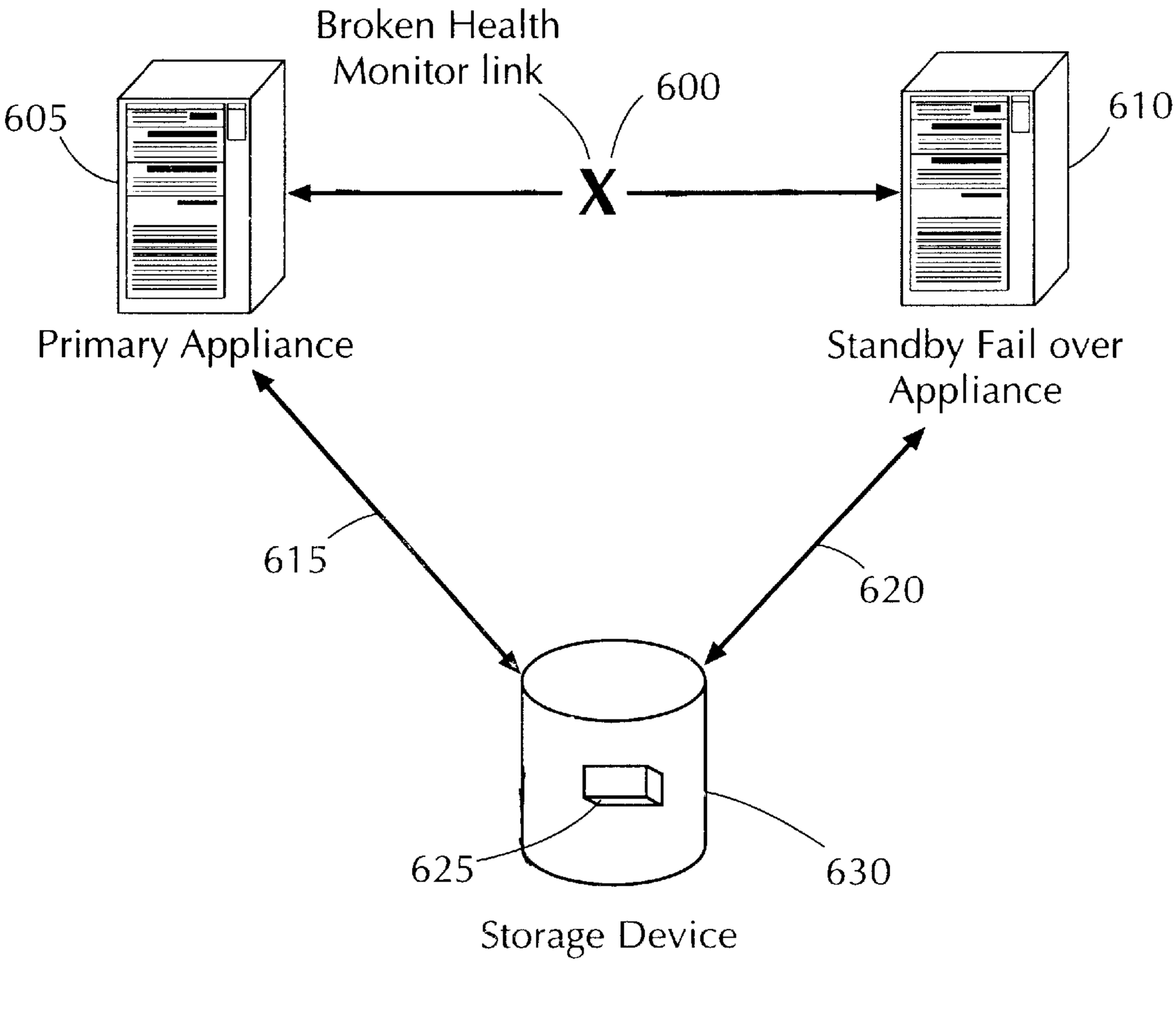

Broken Health
Monitor link
600
605
610
X
Primary Appliance
Standby Fail over
Appliance
615
620
625
630
Storage Device

FIG. 5

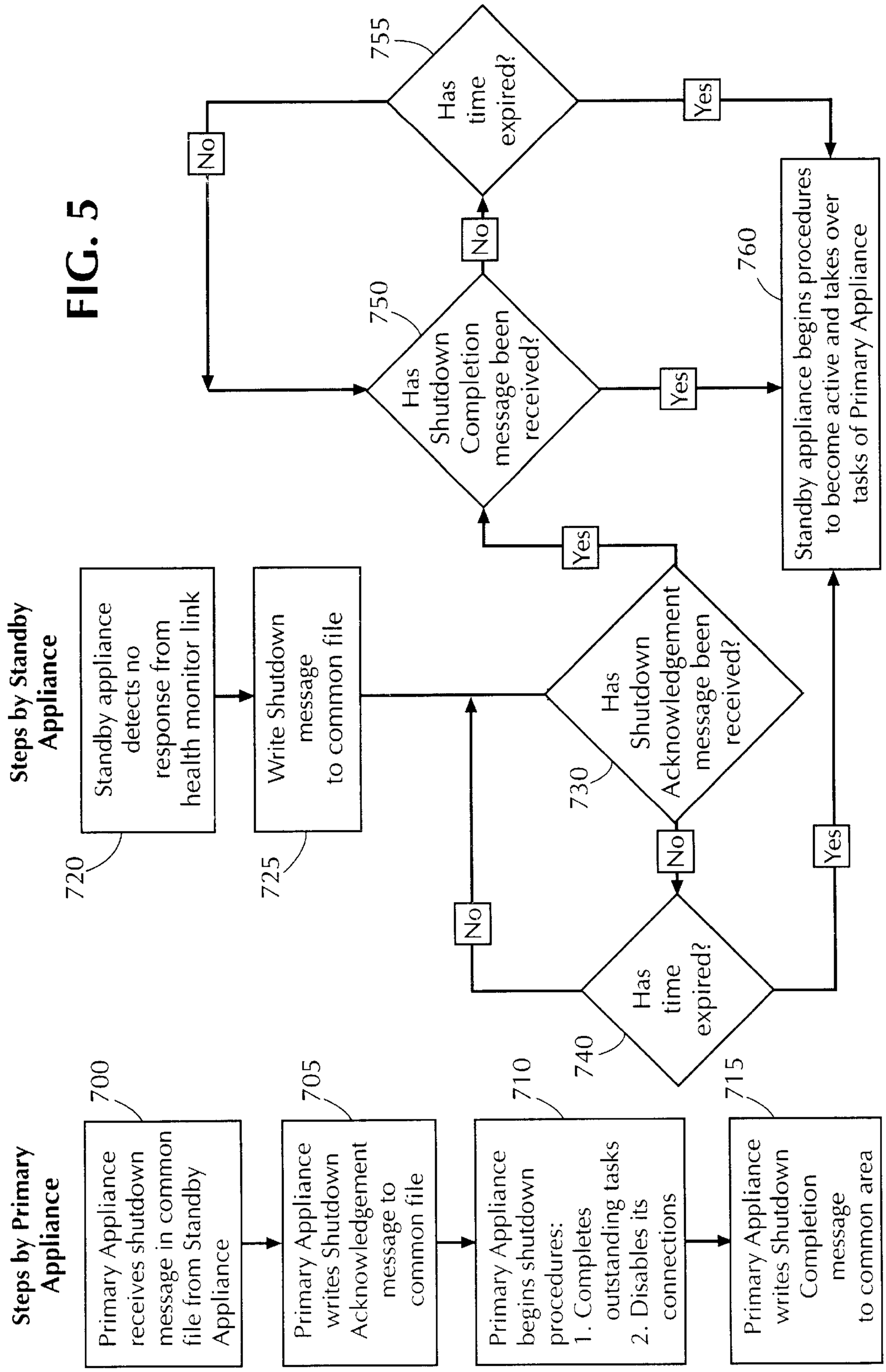

Steps by Standby Appliance
700
Standby appliance detects no response from health monitor link
720
705
Write Shutdown message to common file
725
710
Has Shutdown Acknowledgement message been received?
730
No
Yes
740
Has time expired?
No
Yes
715
Has Shutdown Completion message been received?
750
No
Yes
755
Has time expired?
No
Yes
760
Standby appliance begins procedures to become active and takes over tasks of Primary Appliance
Steps by Primary Appliance
Primary Appliance receives shutdown message in common file from Standby Appliance
Primary Appliance writes Shutdown Acknowledgement message to common file
Primary Appliance begins shutdown procedures:
1. Completes outstanding tasks
2. Disables its connections
Primary Appliance writes Shutdown Completion message to common area

FIG. 6

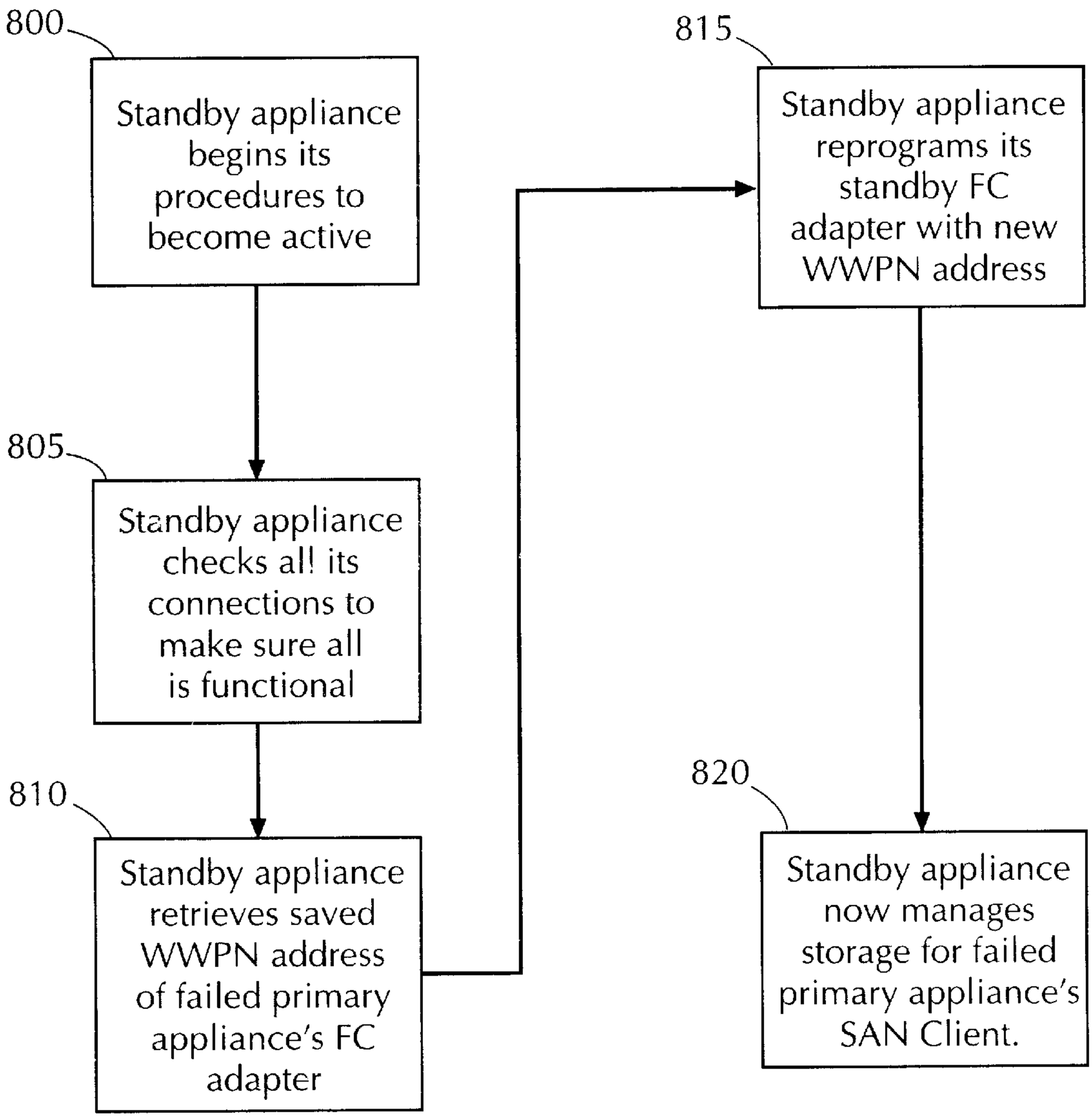
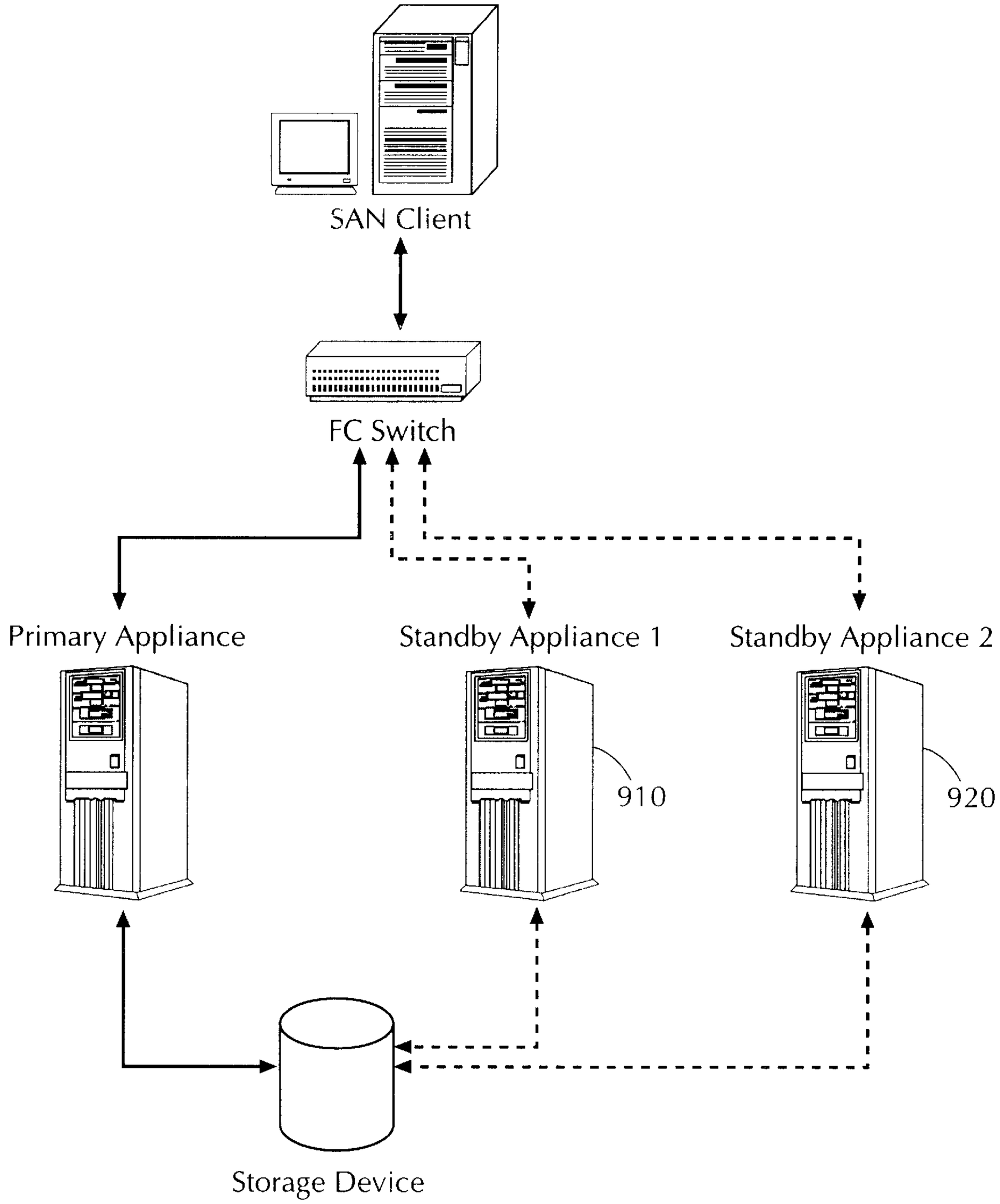

800
Standby appliance begins its procedures to become active
805
Standby appliance checks all its connections to make sure all is functional
810
Standby appliance retrieves saved WWPN address of failed primary appliance's FC adapter
815
Standby appliance reprograms its standby FC adapter with new WWPN address
820
Standby appliance now manages storage for failed primary appliance's SAN Client.

FIG. 7


SAN Client
FC Switch
Primary Appliance
Standby Appliance 1
Standby Appliance 2
910
920
Storage Device

SYSTEM AND METHOD FOR FIBRECHANNEL FAIL-OVER THROUGH PORT SPOOFING

CROSS REFERENCE TO RELATED APPLICATIONS

This application is a continuation-in-part of U.S. patent application Ser. No. 09/792,873, filed Feb. 23, 2001, entitled "Storage Area Network Using A Data Communication Protocol," and is also a continuation-in-part of U.S. patent application Ser. No. 09/925,976, filed Aug. 9, 2001, entitled "System And Method For Computer Storage Security," the disclosures of which are incorporated herein by reference.

BACKGROUND OF THE INVENTION

The present invention concerns "port spoofing," which allows a computer to "fail over" to its secondary fibrechannel connection if its primary fibrechannel connection should fail.

Fibrechannel is a network and channel communication technology that supports high-speed transmission of data between two points and is capable of supporting many different protocols such as SCSI (Small Computer Systems Interface) and IP (Internet Protocol). Computers, storage devices and other devices must contain a fibrechannel controller or host adapter in order to communicate via fibrechannel. Unlike standard SCSI cables, which can not extend more than 25 meters, fibrechannel cables can extend up to 10 km. The extreme cable lengths allow devices to be placed far apart from each other, making it ideal for use in disaster recovery planning. Many companies use the technology to connect their mass storage and backup devices to their servers and workstations.

In addition to being able to protect data through disaster recovery plans and backup, another requirement for a computer data communications network is that the storage devices must always be available for data storage and retrieval. This requirement is called "High Availability." High Availability is a computer system configuration implemented with hardware and software such that, if a device fails, another device or system that can duplicate the functionality of the failed device will come on-line to take its place automatically and transparently. Users will not be aware that a failure and switch-over had taken place if the system is implemented properly. Many companies cannot afford to have downtime on their computer systems for any length of time. High availability is used to ensure that their computer systems remain running continuously in the event of any device failure. Servers, storage devices, network switches and network connections are redundant and cross-connected to achieve High Availability. FIG. **1** shows a typical prior art fibrechannel High Availability configuration.

In the configuration of FIG. **1**, High Availability is achieved by first creating mirrored storage devices **145** and **150** and then establishing multiple paths to the storage devices which are represented by the fibrechannel connections **105**, **110**, **125**, **130**, **135**, and **140**. This configuration allows the server **100** to continuously be able to store and retrieve its data, even if multiple failures have occurred, as long as one of its redundant hardware components or fibrechannel connections does not fail. For example, if paths **110** and **125** fail, the data traffic will be routed through paths **105** and **140** to access storage device **150**. Special software must be running on the server to detect the failures and route the data through the working paths. The software is costly and requires valuable memory and CPU processing time from the server to manage the fail-over process.

SUMMARY OF THE INVENTION

The present invention is a system and method of achieving High Availability on fibrechannel data paths between an appliance's fibrechannel switch and its storage device by employing a technique called "port spoofing." This system and method do not require any proprietary software to be executing on the file/application appliance other than the software normally required on an appliance, which includes the operating system software, the applications, and the vendor-supplied driver to manage its fibrechannel host adapter(s).

The invention includes a system for appliance back-up, in which a primary appliance is coupled to a network, whereby the primary appliance receives requests or commands and sends a status message over the network to a standby appliance, which indicates that the primary appliance is operational. If the standby appliance does not receive the status message or the status message is invalid, the standby appliance writes a shutdown message to a storage device, which is also coupled to the network. The primary appliance then reads the shutdown message stored in the storage device and disables itself from processing requests or commands. Preferably, when the primary appliance completes these tasks, it disables communication connections and writes a shutdown completion message to the storage device. The standby appliance reads the shutdown completion message from the storage device and initiates a start-up procedure, which includes causing the address of the standby appliance to be identical to the primary appliance address and processing the requests or commands in place of the primary appliance. The primary appliance can include a fibrechannel adapter having associated therewith the primary appliance address, and the standby appliance can have a fibrechannel adapter having associated therewith the standby appliance address. The standby appliance can include a standby application, which is identical to a primary application in the primary appliance, for processing the requests or commands.

The invention also includes a method for appliance back-up, which includes sending a status message from a primary appliance to a standby appliance indicating that the primary appliance is operational. If the standby appliance does not receive the status message or the status message is invalid, a shutdown message is written to a storage device. The primary appliance reads the shutdown message stored in the storage device and is disabled from processing requests or commands. The disabling of the primary appliance can include completing tasks, disabling communication connections, and writing a shutdown completion message to the storage device. The standby appliance reads the shutdown completion message from the storage device and initiates a start-up procedure so that a standby application, included in the standby appliance, can process the requests or commands. A standby appliance address is changed to the primary appliance address and the standby appliance processes the requests or commands.

Another method for appliance back-up is disclosed which includes monitoring a primary appliance for an indication of a failure, the primary appliance having a primary appliance address. If the failure occurs, a message is written to a storage device and, in response, the primary appliance is disabled from processing requests or commands. The failure can be the primary appliance not sending the status message

to a standby appliance. The standby appliance has a standby appliance address, which is changed to the primary appliance address so the standby appliance can processes the requests or commands. The standby appliance address and the primary appliance address are world wide port names. The monitoring can include sending a status message to the standby appliance indicating that the primary appliance is operational, or sending a status request message to the primary appliance and receiving an update status message from the primary appliance. The failure message is written if the standby appliance does not receive the status message or if the status message is invalid. Alternatively, the message is written if the standby appliance does not receive the update status message or the update status message is invalid. The disabling can include completing tasks, disabling communication connections, writing a shutdown completion message to the storage device (by the primary appliance), reading the shutdown completion message from the storage device (by the standby appliance), and initiating a start-up procedure. The standby appliance can include a standby application, which is identical to a primary application in the primary appliance, for processing the requests or commands.

One of the primary advantages of the present invention is that additional software is not required to be running on the file/application server. Many system administrators prefer to only install the software that is necessary to run their file/application servers. Many other solutions require special software or drivers to run on the server in order to manage the fail-over procedure.

BRIEF DESCRIPTION OF THE DRAWINGS

These and other features and advantages of the invention will be apparent to those skilled in the art from the following detailed description of preferred embodiments, taken together with the accompanying drawings, in which:

FIG. **1** is a block diagram of a prior art fibrechannel High Availability network configuration;

FIG. **2** is a block diagram of the network configuration of the present invention;

FIG. **3** is a detailed block diagram of FIG. **2**;

FIG. **4** is a block diagram showing a failed health monitor connection and the method used to send a shutdown signal;

FIG. **5** is a flowchart showing the actions of the primary appliance and the standby appliance when the health monitor link or primary appliance is non-functional;

FIG. **6** is a flowchart showing the actions of the standby appliance to become active; and

FIG. **7** is a block diagram showing more than one standby appliance.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

The present invention is based on a software platform that creates a storage area network ("SAN") for file and application servers to access their data from a centralized location. A virtualized storage environment is created and file/application servers can access its data through a communication protocol such as Ethernet/IP, fibrechannel, or any other communication protocol that provides high-speed data transmissions. Fibrechannel is the protocol that will be discussed herein, although it is understood that the other previously mentioned communication protocols are also within the scope of the present invention.

As mentioned before, computers, storage devices and other devices contain a fibrechannel (FC) controller or host adapter in order to communicate via fibrechannel. In the present invention, FC hubs/switches are used to connect file/application servers to servers that manage the storage devices. Storage devices can be RAID (redundant array of independent disks) subsystems, JBODs Oust a bunch of disks), or tape backup devices, for example. An FC switch allows a server with a fibrechannel host adapter to communicate with one or more fibrechannel devices. Without a hub or switch, only a point-to-point or direct connection can be created, allowing only one server to communicate with only one device. "Switch" thus refers to either a fibrechannel hub or switch.

Fibrechannel adapters are connected together by fiber or copper wire via their FC port(s). Each port is assigned a unique address called a WWPN or "world wide port name." The WWPN is a unique 64-bit identifier assigned by the hardware manufacturer and is used to establish the source and destination between which data will travel. Therefore, when an FC device communicates with another FC device, the initiating FC device, or "originator," must use the second FC device's WWPN to locate the device and establish the communication link.

Fibrechannel devices that are connected together by an FC switch communicate on a "fabric." If a hub is employed, then the communication link is called a "loop." On a fabric, devices receive the full bandwidth when they are communicating with each other, and on a loop the bandwidth is shared.

Although the manufacturers assign WWPN addresses, the addresses are not permanently fixed to the hardware. The addresses can be changed. Software can programmatically change the WWPN addresses on the fibrechannel hardware. The present invention employs this feature by changing the WWPN address on a standby FC adapter to the WWPN address used by the failed FC adapter.

The present invention employs storage management software that is capable of running within any kind of computing device that has at least one CPU and is running an operating system. Examples of such computing devices are an Intel®-based PC, a Sun® Microsystems Unix® server, an HP® Unix® server, an IBM® Unix® server or embedded systems (collectively referred to as "appliances"). The software performs the writing, reading, management and protection of data from its file/application servers and workstations, and is disclosed with more specificity in U.S. patent application Ser. No. 09/792,873, filed Feb. 23, 2001, the disclosure of which has already been expressly incorporated herein by reference. One of the protection features of the software is the ability to "fail over" to another appliance if a set of defined failures occurs. The failures are defined and discussed in the following paragraphs.

More specifically, the present invention creates a transparent secondary path for data to flow in the event that a primary data path to a storage device or storage server managing the primary path fails for any reason. The secondary path is a backup communication link to the same storage device. Each computer contains at least one FC host adapter connected to one FC switch. This operation is shown in FIG. **2**, which includes SAN client **200**, FC switch **210**, storage server A **225**, storage server B **230**, and storage device **250**. Attached to each storage server is an FC adapter—primary FC adapter **216** is attached to storage server A **225** and standby FC adapter **217** is attached to storage server B **230**. (There is also an FC adapter, not shown, attached to SAN client **200**.) The primary data path consists of paths **205**, **215**, and **240**, and the transparent

secondary data path consists of paths **220** and **245**. The secondary path **220** is a backup communication link to storage device **250**. If primary path **215** fails, storage server B **230** detects the failure and initiates its standby FC adapter **217** to begin "spoofing" primary FC adapter **216** by copying its identity and causing SAN client **200** to function with standby FC adapter **217** in place of primary FC adapter **216**. Data then flow through backup FC connection **220**, through standby FC adapter **217**, into storage server B **230**, and then to connection **245** to storage device **250**.

FIG. **3** shows a more detailed view of FIG. **2**. Two appliances, a primary appliance **525** and a standby appliance **530** are running the above-described software. The appliances can be computers, for example, personal computers, servers, or workstations. Standby appliance **530** is a fail-over appliance. The two appliances **525**, **530** are connected to the same storage device **550** and to FC switch **510**. The storage device **550** can be any kind of device that stores data important enough to require protection from failure such as a hard disk, a RAID system, a CDROM, or a tape backup device. SAN client **500**, which is a file/application server or workstation, is configured with two separate data paths, a primary path made up of paths **515** and **540**, and a standby path, made up of paths **520** and **545**. Paths **515** and **520** always use a fibrechannel medium/protocol, but paths **540** and **545** may use fibrechannel, or may use a different medium/protocol such as SCSI, IDE (Integrated Drive Electronics) or any other storage medium/protocol. Although one SAN client is shown in the example of FIG. **3**, in an actual production configuration, a primary appliance may manage the storage needs for multiple SAN clients. Data are actively transmitted bi-directionally over primary data paths **515**, **540** between SAN client **500**, primary appliance **525** and storage device **550** (as long as primary appliance **525** and its paths **515** and **540** remain in good working order). No data will be transmitted bidirectionally over standby paths **520**, **545** between SAN client **500** and storage device **550**. However, standby appliance **530** may or may not be data active (i.e., ready to receive or receiving data from the SAN client) depending on its configuration.

This standby appliance **530** can be implemented strictly as a fail-over appliance for one or more primary appliances. If its only function is to standby, then standby appliance **530** must wait for one of the primary appliances to fail so that it can become data active. If a standby appliance **530** is a fail-over appliance for more than one primary appliance **525**, then it must contain one dedicated standby FC adapter **517** for each primary appliance **525**, and it must have a dedicated connection to each storage device **550** that it might need to manage. Standby appliance **530** itself can also be a primary appliance to its own set of SAN clients and storage devices **550**. The operations of being both a primary and standby appliance are multitasked.

Standby appliance **530** monitors the status or the "health" of its primary appliance **525** through a communications link called the health monitor link **535**. Messages called "fail-over heartbeats" are sent from standby appliance **530** to primary appliance **525**, and if the messages are properly acknowledged the status of primary appliance **525** is acceptable. A "heartbeat" system is disclosed with more specificity in U.S. patent application Ser. No. 09/925,976, filed Aug. 9, 2001, entitled "System And Method For Computer Storage Security," the disclosure of which has already been expressly incorporated herein by reference. If the heartbeat is not properly acknowledged or not acknowledged at all, then standby appliance **530** will begin the procedure for taking over the tasks of primary appliance **525**. The heartbeat can also be implemented such that the heartbeat is sent from primary appliance **525** to standby appliance **530**; this simply is a choice based on the software's architecture and ease of implementation. If a standby appliance **530** is a fail-over appliance for multiple primaries, the communications link can be configured to be shared among all primary appliances **525** or one dedicated communications link can be connected from each primary appliance **525** to standby appliance **530**. The communications link can be any type of medium or protocol such as, for example, an Ethernet IP connection, a fibrechannel connection or a serial connection. It is also possible that the health monitor can also function from standby FC adapter **517** along standby path **520** to monitor the status of the primary appliance.

The health monitor link **535** performs several tasks:

1. It is used to monitor the status of the primary appliance. The standby appliance sends a request for the primary appliance's status. This is the heartbeat. The primary appliance sends the status data to the standby appliance, and the data are then analyzed. If a problem is discovered, the standby appliance will instruct the primary appliance to shut down.
2. Health monitor link **535** is used to initially transfer all the required information from the primary appliance to the standby appliance that is needed to emulate the primary appliance in the event that a fail-over event takes place when the standby appliance was assigned as the fail-over appliance for the primary appliance. This information includes the operating parameters and data for the primary appliance and is static. "Static" means that the parameters do not change during the operation of the primary appliance. If the parameters are changed due to new requirements and needs by the user, the primary appliance will transfer the new information to the standby appliance. An alternative implementation is that the standby appliance is notified of the change and a request is sent from the standby appliance to the primary appliance to retrieve the new set of parameters. Currently the first method is used (request from primary appliance to standby appliance) but future implementations due to evolution of the fail-over feature may require the latter method.
3. Health monitor link **535** is used to transfer any information from the primary appliance to the standby appliance at the time of fail-over if the primary appliance continues to run. This information is used to help smooth the standby appliance's fail-over process. This information is dynamic and is not required by the standby appliance—the information is merely helpful. The information is dynamic because its content is based on its current operating state. The information is not required because if the primary appliance failure were due to a system crash, the standby appliance would not be able to receive this information.
4. Health monitor link **535** is used by the primary appliance to inform the standby appliance to begin taking over if the primary appliance discovers a problem where it becomes necessary for the primary appliance itself to initiate the fail-over process.
5. Health monitor link **535** is used by the standby appliance to inform the primary appliance to shut itself down so that the standby appliance can take over the primary appliance's tasks if it detects over its health monitor link an imminent failure of the primary appliance.
6. Health monitor link **535** is used by the standby appliance to inform the primary appliance to resume its FC

activities when the primary appliance's failure has been fixed. The standby appliance does this by maintaining its connection with the primary appliance even though the primary appliance is no longer active to receive or send commands and data. The primary appliance continues to send status data to the standby appliance. When the problem affecting the primary appliance has been repaired, the standby appliance will be informed via the status data, whereby the standby appliance will begin de-activating itself from receiving additional commands and data from the SAN client and will instruct the primary appliance to begin its start-up procedure to resume receiving commands and data from the SAN client once again.

Standby appliance **530** also takes over its primary appliance's tasks if health monitor link **535** is broken or the heartbeat is not acknowledged. Health monitor link **535** may be broken due to a cut cable or "accidental" removal. The heartbeat may not be acknowledged because primary appliance **525** loses power, crashes, or incurs another similar event. Although a broken link **535** does not affect the ability of primary appliance **525** to perform its tasks, primary appliance **525** will be regarded as a failed appliance nonetheless, and standby appliance **530** will take steps to begin to take over the tasks from primary appliance **525**. Since standby appliance cannot communicate to primary appliance **525** to shut itself down, a backup method is used to pass on the shutdown signal.

FIG. **4** illustrates a failed health monitor connection **600** and the method used to send a shutdown signal. Since primary appliance **605** and standby appliance **610** are connected to the same storage device **630**, storage device **630** will become the medium used to pass the shutdown signal to primary appliance **605**. A common file or a disk sector (or sectors) **625** is reserved on the storage device **630**. Primary appliance **605** monitors the common file or disk sector **625** at regular, pre-defined intervals for instructions from standby appliance **610**. If standby appliance **610** detects no acknowledgement from its heartbeats or there is a broken health monitor link, the standby appliance writes into common file **625** an instruction for primary appliance **605** to begin its shutdown procedures, which include completing outstanding tasks to its application/file servers and/or workstation and disconnecting itself from the fibrechannel communication network. If primary appliance **605** is alive, which means that the health monitor link is corrupted, the primary appliance reads the shutdown signal from the common file **625** and writes an acknowledgement into the common file **625** that it has received the shutdown signal and is beginning its shutdown procedure. Standby appliance **610** then waits a pre-determined amount of time for a message to come through the common file **625** from primary appliance **605** that the latter has completed its shutdown procedure. Standby appliance **610** monitors the common file **625** for the completion message during this time interval, and begins its start-up procedures as soon as the completion message is given. When the shutdown procedure is completed by primary appliance **605**, primary appliance then writes a shutdown completion message to common file **625**, and standby appliance **610** begins its procedure to become active and take over the tasks of its failed primary appliance **605**. If standby appliance **610** does not receive a shutdown completion message from primary appliance **605** within a predetermined time interval, standby appliance **610** assumes that primary appliance **605** has become totally inoperative and initiates its procedures to become active to take over the tasks of the failed primary appliance **605**. Since common file **625** is used as a backup communication link between the appliances, it is also used to communicate any dynamic information from the primary appliance to the standby appliance that may be helpful to the fail-over process. This information can be historical and/or state information, which can be used during start-up procedures by either appliance. For example, if the primary appliance is turned off followed by the standby appliance being turned off, the standby appliance writes a message to the storage device indicating that it is no longer operating in place of the primary server. If the primary appliance resumes operation before the standby appliance, the primary appliance knows from reading the message that it is to resume processing commands and requests. As stated earlier, this information is not required for the fail-over process—it simply makes the process easier.

If primary appliance **605** initially becomes inoperative because of loss of power, system crash, or some other catastrophic event, standby appliance **610** writes its shutdown message to the common file **625** with the assumption that primary appliance **605** may still be active. Standby appliance **610** functions in this manner because it cannot be assumed that primary appliance **605** is totally inoperative. A predetermined time interval is given by standby appliance **610** for primary appliance **605** to respond to the shutdown message, and if the shutdown message is not acknowledged standby appliance **610** begins its procedures to become active to take over the tasks of the failed primary appliance **605**. Standby appliance **610** monitors the common file **625** for the shutdown acknowledgement message, and as soon as this message is received standby appliance **610** waits for the shutdown completion message.

FIG. **5** is a flowchart which describes the actions taken by primary appliance **605** and standby appliance **610** when the health monitor link or primary appliance is non-functional. Blocks **700** through **715** illustrate the steps undertaken by primary appliance **605**. At block **700**, primary appliance **605** receives the shutdown message in common file **625** from standby appliance **610**. Primary appliance **605** writes a shutdown acknowledgment message to common file **625** at block **705**. At block **710**, primary appliance **605** begins its shutdown procedure by completing outstanding tasks and disabling its connections. Finally, at block **715**, primary appliance **605** writes its shutdown completion message to common file **625**.

Blocks **720** through **760** detail the steps employed by standby appliance **610**. At block **720**, standby appliance **610** detects the lack of a response from the health monitor link. In step **725**, standby appliance **610** next writes the shutdown message to common file **625**. The program proceeds to blocks **730** and **740** to wait for a shutdown acknowledgment message from primary appliance **605**. Block **730**, which queries whether the shutdown acknowledgment message has been received from primary appliance **605**. If the answer is "NO," the program proceeds to decision block **740**, which queries whether the predetermined time period has expired. If the answer at decision block **740** is "NO," the program loops back to block **730**. If the answer at decision block **740** is "YES," the program proceeds to block **760** where standby appliance **610** begins procedures to become active and to take over the tasks of primary appliance **605**. Returning to decision block **730**, if the answer to the query is "YES," the program proceeds to blocks **750** and **755** where standby appliance **610** waits for the shutdown completion message from primary appliance **605**. In decision block **750**, the program queries whether the shutdown completion message has been received from primary appliance **605**. If the answer

is "NO," the program proceeds to decision block **755**, which queries whether the predetermined time period has expired. If the answer at decision block **755** is "NO," the program loops back to block **750**. If the answer at decision block **755** is "YES," the program proceeds to block **760** where standby appliance **610** begins procedures to become active and to take over the tasks of primary appliance **605**. Returning to decision block **750**, if the answer to the query is "YES," the program again proceeds to decision block **760**, as discussed immediately above.

After the shutdown completion message is received or after the time has expired waiting for the shutdown acknowledgement or completion messages, the standby appliance begins its procedures to become active. From FIG. **3**, standby appliance **530** reprograms its standby FC adapter **517** with the WWPN address from primary FC adapter **516**. Standby FC adapter **517** was given a temporary WWPN address in order for it to be connected to the fibrechannel fabric. Standby appliance **530** knows the WWPN address of the primary appliance because when standby appliance **530** was initially assigned to be the fail-over appliance for primary appliance **525**, it communicated with primary appliance **525** to transfer all the necessary information it needed to perform the emulation. This information included the WWPN address of primary FC adapter **516**.

A flowchart in FIG. **6** shows the steps taken by standby appliance **530**. At block **800**, standby appliance **610** initiates its activation procedures. Standby appliance **610** checks its connection at block **805** to ensure functionality. At block **810**, standby appliance **610** retrieves the saved WWPN address of the FC adapter of failed primary appliance **605**. Standby appliance **610** reprograms its standby FC adapter with the new WWPN address at block **815**. Finally, at block **820** standby appliance **610** is functionally able to manage storage for the SAN client of failed primary appliance **605**, in a manner transparent to the SAN client.

Once the WWPN address is programmed into standby FC adapter **517**, SAN client **500** will not be aware of the change in appliances. Standby appliance **530** will now receive all the data traffic that was bound for failed primary appliance **525**. When a standby appliance is a fail-over appliance for one or more than one primary appliances, a table is kept to store and keep track of the information needed to emulate the primary appliances, which includes the WWPN addresses.

The technology of the present invention is not limited to one standby appliance that can act as a fail-over to a set of primary appliances. As illustrated in FIG. **7**, the present invention also encompasses having a standby fail-over appliance **910** acting as a fail-over appliance to another standby fail-over appliance **920**. In this way, such multiple backup systems protect businesses' computer and storage systems from failing.

It should be understood by those skilled in the art that the present description is provided only by way of illustrative example and should in no manner be construed to limit the invention as described herein. Numerous modifications and alternate embodiments of the invention will occur to those skilled in the art. Accordingly, it is intended that the invention be limited only in terms of the following claims.

What is claimed is:

1. A system for appliance back-up comprising:

a network;

a storage device coupled to the network; and

a primary appliance and a standby appliance coupled to the network, the primary appliance receiving requests or commands and sending a status message via the network to the standby appliance indicating that the primary appliance is operational,

wherein if the standby appliance does not receive the status message or the status message is invalid:

the standby appliance writes a shutdown message to a storage device,

the primary appliance reads the shutdown message stored in the storage device and disables itself from processing requests or commands, and

the standby appliance causes a standby appliance address to be identical to a primary appliance address and processes the requests or commands.

2. The system of claim **1**, wherein the primary appliance completes tasks and disables communication connections.

3. The system of claim **2**, wherein the primary appliance writes a shutdown completion message to the storage device.

4. The system of claim **3**, wherein the standby appliance reads the shutdown completion message from the storage device and initiates a start-up procedure.

5. The system of claim **1**, wherein the primary appliance includes a primary application and the standby appliance includes a standby application, the standby application being identical to the primary application.

6. The system of claim **1**, wherein the primary appliance includes a first fibrechannel adapter having associated therewith the primary appliance address and the standby appliance includes a second fibrechannel adapter having associated therewith the standby appliance address.

7. A method for appliance back-up comprising:

sending a status message from a primary appliance to a standby appliance indicating that the primary appliance is operational;

if the standby appliance does not receive the status message or the status message is invalid:

writing a shutdown message to a storage device;

reading the shutdown message stored in the storage device;

disabling the primary appliance from processing requests or commands;

causing a standby appliance address to be identical to a primary appliance address; and

causing the standby appliance to process the requests or commands.

8. The method of claim **7**, wherein the disabling further comprises completing tasks and disabling communication connections.

9. The method of claim **7**, wherein the disabling further comprises writing a shutdown completion message to the storage device.

10. The method of claim **9**, further comprising:

reading the shutdown completion message from the storage device; and

initiating a start-up procedure.

11. The method of claim **7**, wherein the primary appliance includes a primary application and the standby appliance includes a standby application, identical to the primary application, for processing the requests or commands.

12. A method for appliance back-up comprising:

monitoring a primary appliance for an indication of a failure, the primary appliance having a primary appliance address,

wherein if the failure occurs:

writing a message to a storage device;

in response to the message, disabling the primary appliance from processing requests or commands;

causing a standby appliance address of a standby appliance to be identical to the primary appliance address; and

processing the requests or commands.

13. The method of claim **12**, wherein the monitoring further comprises sending a status message to the standby appliance indicating that the primary appliance is operational.

14. The method of claim **12**, wherein the monitoring further comprises sending a status request message to the primary appliance and receiving an update status message from the primary appliance.

15. The method of claim **13**, wherein the failure is the status message is not sent to the standby appliance.

16. The method of claim **13**, wherein the message is written if the standby appliance does not receive the status message or the status message is invalid.

17. The method of claim **16** wherein the disabling further comprises completing tasks and disabling communication connections.

18. The method of claim **17**, wherein the disabling further comprises writing a shutdown completion message to the storage device.

19. The method of claim **18**, further comprising:

reading the shutdown completion message from the storage device; and

initiating a start-up procedure.

20. The method of claim **14**, wherein the message is written if the standby appliance does not receive the update status message or the update status message is invalid.

21. The method of claim **20**, wherein the disabling further comprises completing tasks and disabling communication connections.

22. The method of claim **21**, wherein the disabling further comprises writing a shutdown completion message to the storage device.

23. The method of claim **12**, wherein the standby appliance address and the primary appliance address are world wide port names.

24. The method of claim **12**, wherein the primary appliance includes a primary application and the standby appliance includes a standby application, identical to the primary application, for processing the requests or commands.

* * * * *

UNITED STATES PATENT AND TRADEMARK OFFICE

CERTIFICATE OF CORRECTION

PATENT NO. : 6,715,098 B2
DATED : March 30, 2004
INVENTOR(S) : Chen et al.

It is certified that error appears in the above-identified patent and that said Letters Patent is hereby corrected as shown below:

Column 4,
Line 5, changed from "Oust" to -- (Just --.

Signed and Sealed this

Twenty-ninth Day of June, 2004

JON W. DUDAS
Acting Director of the United States Patent and Trademark Office